

-18-

**Claims:**

1. An automotive fuel injector leakage tester (10) comprising a mount (22) for such an injector (32) and a flowmeter (66) of sufficient sensitivity arranged to  
5 measure leaked fuel flow rates through the nozzle (34) of such an injector (32), **characterised in that** the tester (10) is further provided with an interface passageway (58) which enables fluid communication between the injector nozzle (34) and the flowmeter (66) when the  
10 tester (10) is in use, in which such an injector (32) contains a first liquid when under test to supply such liquid to the injector nozzle (34) so that such liquid can leak therethrough into the interface passageway (58), and in which the interface passageway (58) contains a  
15 second liquid which is immiscible with the first liquid, the tester (10) being so constructed that the interface between the first and second liquids remains within the interface passageway (58) whilst the flowmeter (66) provides a measure of the leakage of the first liquid  
20 through the nozzle (34) of such an injector (32).
2. An automotive fuel injector leakage tester according to claim 1, **characterised in that** the flowmeter (66) also contains the said second liquid, so that it provides a measure of the leakage flow rate through the nozzle (34)  
25 of the injector (32) under test by virtue of displacement of the second liquid through it owing to the said first liquid displacing some of the said second liquid from the

-19-

interface passageway (58).

3. An automotive fuel injector leakage tester according to claim 1 or claim 2, **characterised in that** the injector (32) is positioned above the interface passageway (58) with the said first liquid being of a lower density than the said second liquid.

4. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** the said first liquid comprises a test oil.

5. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** the said second liquid comprises water.

6. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** the flowmeter (66) comprises a measurement passageway (76) of sufficiently small cross-section to enable a flow rate to be measured which is as low as automotive fuel injector leakage flow rates.

7. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** the flowmeter (66) measures flow rates via heat transfer detection means (80, 82, 84) which serve to detect heat transferred by liquid passing through the measurement passageway (76), to provide a measure of the flow rate thereof.

8. An automotive fuel injector leakage tester according to claim 7, **characterised in that** the measurement

-20-

passageway (76) is provided with a heating element (78) positioned to heat fluid within the measurement passageway (76), and a temperature sensor (82) is provided downstream of the heating element (78) to  
5 provide an output which is indicative of the flow rate.

9. An automotive fuel injector leakage tester according to claim 8, **characterised in** that the temperature sensor (82) comprises a thermocouple (82).

10. An automotive fuel injector leakage tester according  
10 to claim 8 or claim 9, **characterised in that** a further temperature sensor (80) is arranged upstream of the heating element (78) to provide a measure of the temperature of liquid flowing within the measurement passageway (76) before it reaches the heating element  
15 (78).

11. An automotive fuel injector leakage tester according to claim 10, **characterised in that** the further temperature sensor (80) comprises a thermocouple (80).

12. An automotive fuel injector leakage tester according  
20 to claim 11, **characterised in that** the flowmeter (66) takes account of the temperature of the incoming liquid, and adjusts the output from the first temperature sensor (82) accordingly so that the output of the flowmeter (66) is substantially independent of the temperature of the  
25 incoming liquid.

13. An automotive fuel injector leakage tester according to claim 12, **characterised in that** the rôles of the two

-21-

temperature sensors (80, 82) are selectively reverseable so that the flowmeter (66) can measure flow rates of liquids in both directions of flow through the measurement passageway (76).

5 14. An automotive fuel injector leakage tester according to any one of claims 1 to 6, **characterised in that** the flowmeter (66) comprises a micro turbine.

15. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** the  
10 interface passageway (58) comprises a tube (58) connected to the flowmeter (66) at one of its ends, and provided with a seal (64) at its other end adapted for sealing engagement with the nozzle end (34) of such an injector (32).

15 16. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** a reverse feed device (70, 72, 74) is connected in fluid communication with the flowmeter (66) on the other side thereof to that of the injector (32).

20 17. An automotive fuel injector leakage tester according to claim 16, **characterised in that** the reverse feed device (70, 72, 74) comprises a reservoir (72) of the said second liquid to an upper surface of which is connected a source of pressurised gas to force the flow  
25 of fluid through the flowmeter (66) in the reverse direction to which such fluid flows through the flowmeter (66) during a leakage measurement.

18. An automotive fuel injector leakage tester according to claim 17, **characterised in that** a control is provided to ensure that the amount of liquid flowing through the  
5 flowmeter (66) in the second direction is equal to the amount of fluid which flowed through it during the leakage measurement.

19. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** the amount  
10 of liquid which flows through the flowmeter in the second direction returns the interface between the two liquids to the seal end (64) of the interface passageway (58).

20. An automotive fuel injector leakage tester according to any preceding claim, **characterised in that** a drive  
15 (42) is provided to bring about relative linear movement between the injector (32) and the interface passageway (58) to bring them into and out of sealing engagement with one another.

21. An automotive fuel injector leakage tester according  
20 to any preceding claim, **characterised in that** the tester (10) has a bath (46) of the said first liquid, and that end of the interface passageway (58) which is brought into contact with the injector (32) is immersed in that bath (46).

25 22. An automotive fuel injector leakage tester according to claim 21, **characterised in that** the axis of the injector (32) is aligned with the direction of relative

-23-

movement between the injector (32) and the interface passageway (58), the nozzle end (34) of the injector (32) has a face which is generally transverse of that axis, and the line of movement is on a slant so that as the  
5 nozzle end (34) of the injector (32) dips into the bath (46) of the said first liquid, the line of contact between the generally horizontal surface of that liquid and the nozzle end (34) of the injector (32) sweeps across the face thereof, and more readily enables removal  
10 of air that might otherwise become trapped between the nozzle end (34) of the injector (32) and the interface passageway (58).

23. A method of testing an automotive fuel injector for leakage, **characterised in that** a tester (10) is used  
15 which is as claimed in any preceding claim.

24. A method of testing an automotive fuel injector for leakage, **characterised in that** a first liquid is allowed to leak from the nozzle (34) of an injector (32) under test into an interface passageway (58) which contains a  
20 second liquid and which provides fluid communication between the injector nozzle (34) and a flowmeter (66), the second liquid being immiscible with the first, and the interface between the first and second liquids remaining within the interface passageway (58) whilst the  
25 flowmeter (66) provides a measure of the leakage of the first liquid through the nozzle (34) of such an injector (32).

-24-

25. A method of bringing about a sealing engagement between two components (32 and 58) in such a fashion as to reduce the likelihood of air being trapped between them, **characterised in that** the two components (32 and 5 58) are brought together by relative linear motion along a first imaginary line which is on a slant, and in which one end of the lower of the components is immersed in a bath (46) of liquid, and in which the upper (32) of the components has an end face (34) which is transverse of 10 that line, so that a second imaginary line, being the line of contact between the surface of the liquid and the said end face (34) as the latter dips into the bath (46) sweeps across that end face enabling air which would otherwise be trapped between the two components (32 and 15 58) before they are brought together to escape.

26. An automotive fuel injector leakage tester (10) comprising a mount (22) for such an injector (32) and a flowmeter (66) of sufficient sensitivity arranged to measure leaked fuel flow rates through the nozzle of such 20 an injector, **characterised in that** the flowmeter (66) comprises a measurement passageway (76) of sufficiently small cross-section to enable a flow rate to be measured which is as low as automotive fuel injector leakage flow rates, and heat transfer detection means (80, 82, 84) 25 which serve to detect heat transferred by liquid passing through the measurement passageway (76), to provide a measure of the flow rate thereof.

-25-

27. An automotive fuel injector leakage tester according to claim 26, **characterised in that** the same fluid is used for the fluid which passes at leakage flow rates through the nozzle (34) of the injector (32), as the fluid which  
5 passes through the flowmeter (66).

28. An automotive fuel injector leakage tester according to claim 27, **characterised in that** the fluid comprises water.

29. An automotive fuel injector leakage tester according  
10 to claim 27, **characterised in that** comprises alcohol.

30. A master leak (94) for use in calibrating an automotive fuel injector leakage tester (10), **characterised by** a capillary tube (100) and pressure regulating means (106) connected to apply pressure to a  
15 fluid within the capillary tube (100).

31. A master leak (94) according to claim 30, **characterised in that** the master leak (94) has an outer shape which corresponds to that of an automotive fuel injector (32).

20 32. A master leak according to claim 30, **characterised in that** it is provided with a filter (102) to inhibit blockage of the capillary tube (100).

33. A master leak according to claim 30 or claim 31, **characterised in that** it is provided with an upper seal  
25 to simulate an injector upper seal.

34. A master leak according to any one of claims 30 to 33, **characterised in that** the pressure regulating means



-26-

comprise a regulator valve.

35. A master leak according to any one of claims 30 to 33, **characterised in that** the pressure regulating means comprise a head of fuel in a tube (108).

5 36. A master leak according to any one of claims 30 to 35, **characterised in that** the capillary tube (100) has a diameter of between 0.2mm and 0.025mm.